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"Ricardo Meets China, India and U.S. Three Hundred Years Later"

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Ricardo Meets China, India and U.S. Three Hundred Years Later

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Abstract

As our trading world becomes more globalized, who benefits and who gets hurt? This paper relies on the Ricardian model to explore the effects of technological improvements in underdeveloped countries on the welfare of developed countries. For example, trading between the United States and China, which has undergone a technological improvement in commodities which China imports and exports, may lead to different welfare implications for both countries. The paper models several scenarios to indicate and demonstrate the arguments for and against globalization. The findings suggest that certain policies should be implemented to maintain and enhance the competitiveness of developed countries.

JEL Classification: F0, F1, O, O1, O3, D51

Key Words: International trade; Ricardian Model; Samuelson; Gainers and losers from trade; East-West trade; North-South Trade; China; India; United States; Outsourcing.

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Ricardo Meets China, India and U.S. Three Hundred Years Later

I. Introduction.

In a recent article, Samuelson (2004) rejects the idea that outsourcing is always beneficial for advanced industrialized countries whose workers are being laid off and replaced by others from underdeveloped countries. He quotes prominent mainstream economists who are supporters of outsourcing to low-wage countries like China and India. These economists claim that the job losses in America are only temporary. For example, Irwin (2002, 2004) asserts that only in the short run the American workers may suffer; however in the long run, the labor markets forces will adjust in a way that such outsourcing will be beneficial for America.

Furthermore, Bhagwati, Panagariya, and Srinivasan (2004) claim that the fears that offshore outsourcing will lead to high-value jobs being replaced by low-value jobs are implausible in view of several qualitative arguments to the contrary. They argue that outsourcing leads to gains from trade. For extensive defense in favor of globalization, see papers by Bhagwati (Bhagwati, 2004A, 2004B, and 2004C). Samuelson quotes his own work (1972) and others (Johnson and Stafford, 1993, and Gomory and Baumol, 2000), asserting that in a globalized world, technological improvements in underdeveloped countries (i.e., China and India) may harm the economic growth and the standard of living of workers in developed countries in the long run.

This paper provides some rational insight into the puzzle of what may be called "controversial global trade." Using a theoretical construct of a simple Ricardian trade model, the paper shows that technological improvements in the East have welfare implications on people in both the East and the West. The paper repeats some of the scenarios used by Samuelson (2004) and subjects them to additional thought experiments. The effects on these scenarios are analyzed and examined. Additionally, the scenario of a specialized labor force is developed. The models are used to indicate and demonstrate the arguments for and against globalization.

The findings of this paper should encourage economists who specialize in trade and management, as well as political economists, international business scholars, and policy makers to be conscious of the potential negative effects of continued outsourcing and globalization. The recognition of the potential negative effects of outsourcing may encourage the implementation of policies that will maintain and improve the competitiveness of the developed Western countries. Such an appreciation of the potential pitfalls of increasing outsourcing may lead to policies that call for the developed countries to increase investment in their own human capital and technological know-how so as to secure their strength and standing in the international markets.

In investigating the issue of the influence of technological progress on national welfare we follow Samuelson (2004) and rely on the well-known Ricardian (1817) model. The leading international trade textbook, written by 2008 Nobel Laureate Paul Krugman and by Maurice Obstfeld (Krugman and Obstfeld, 2009, page 48), asserts that the Ricardian theory is "an extremely useful tool for thinking about the reasons why trade may happen and about the effects of international trade on national welfare." They proceed by posing the questions: "Is the (Ricardian) model a good fit to the real world? Does the Ricardian model make accurate predictions about actual international trade flows?" They conclude by writing: "The basic prediction of the Ricardian model… has been strongly confirmed by a number of studies over the years."[1]

In several models, the matter of redistribution of income between factors within a country is discussed in the context of international trade. Theorems developed by Heckscher-Ohlin (1933), Ohlin (1933), Stolper and Samuelson (1941), and Rybczynski (1955) are all modeled with two factors, two goods and two countries. For a recent elaboration of the Hechksher-Ohlin models and the Rybczynski theorem in the context of intermediate goods see for examples, Luthje (2006), in this Journal. Luthje (2006) shows in a theoretical paper that the potential trade pattern becomes much more varied and significantly distinct from the traditional Heckscher-Ohlin model. Luthje (2006) even finds conditions for what he called "reversed Heckscher-Ohlin model."[2]

The discussion above with regards to the Heckscher-Ohlin model, and the Stolper-Samuelson (1941) and Rybczynski (1955) theorems deals with redistribution concerns *within* the countries, where one group (i.e. laborers) gains and one group (i.e. capitalists) loses as a result of opening the market to international trade, and vice versa for the other trading partner. The model presented in this paper however, deals only with the distributional effects *between* the trading countries. In order to make the point as clearly as possible, the paper refrains from the question of intra country's distributional effects. The model presented in this paper has only one factor of production and thus cannot be used to analyze welfare effects within countries.[3]

Consequently, we focus on this issue of welfare inequality *between* countries based on the simple Ricardian (1817) model. This is the case of one input, Labor, where workers are also the consumers whose utility function is unique. We concentrate on how these changes in inequality and welfare distribution may affect the advantages and benefits from international trade.

The remainder of the paper is divided into four sections. Section II presents the assumptions of the model and describes the benchmark case model; Section III revises the benchmark model to include different scenarios due to various technological improvements in one of the trading partner. Section IV extends the model to handle population growth. Section V concludes by presenting general implications of the model.

II. The Model

This section introduces the assumptions and develops the basic results derived from the model. The first five assumptions below follow Ricardo (1817) and Samuelson (2004). The sixth assumption is made for simplicity of exposition and calculation.

Assumptions of the model:

1. There are only two countries in the World: the United States (a developed country) and China (an underdeveloped country).
2. The U.S. is significantly more efficient (has an absolute advantage) in the production of two goods, Good X and Good Y.
3. For each country, the total national pie is equally distributed between all working citizens.
4. Each worker is also a consumer.
5. The production function in both countries is linear with respect to the one input, labor, exhibiting constant unit costs.
6. The utility functions from consumption of goods X and Y identify them as full complement goods i.e., $U_i = \text{Min}[X_i, Y_i]$. They are assumed to be identical for

each individual in both countries. This assumption is introduced for simplicity of exposition and calculation.

Based on the simplified assumptions above, we develop scenarios under which technological changes in one country may diminish the potential benefit of trade between the two trading countries. This may cause a redistribution of welfare, affecting consumers in one or both countries, which may significantly reduce or even eliminate the benefit from international trade.

The aim of the scenarios presented is to show the implications of the model for possible and reasonable values of the parameters. The existence of such scenarios serves as an indicator to political economists, international business scholars, and policy makers of the potential danger in blindly following free trade measures as the sole available policy. The particular values are chosen for simplicity and clarity of the derivation of the results. The fact that this paper derives such results within a simple model is an attribute of this study, since it directs attention to the plausibility of such outcomes.

Scenario 1: The Baseline Case

Assume that there are 10 American workers and 100 Chinese laborers. The American worker can produce either 0.5 units of Good X or 1 unit of Good Y. Based on the assumptions above, the Ricardian Production Possibilities Frontier (PPF), which is identical to the Consumptions Possibilities Frontier (CPF) in autarky, is equal to:

(1) $2X + Y = 10.$

The Profile of the Chinese worker is as follows: He can produce only 0.1 units of Good X or 0.05 units of Good Y. Thus, the Ricardian Production Possibilities Frontier for the Chinese economy is equal to:

(2) $10X + 20Y = 100$

Note that the American worker has an absolute advantage in producing both Goods X and Y. However, an American worker has a comparative advantage in Good Y whereas a Chinese worker has a comparative advantage in Good X.

Assume that the utility function of each consumer is given as:

(3) $u_A = \text{Min}\,[x_A, y_A] = u_C = \text{Min}[x_C, y_C]$

where u_A, x_A and y_A represent the utility and quantities consumed by an American consumer and u_C, x_C and y_C represent those of a Chinese consumer.

Under autarky, the solution is that both countries produce exactly the same amount of each good, i.e., $X_A = Y_A$, and $X_C = Y_C$. Using the relationships in Equations (1) and (2) leads to the autarky solution:

$X_A = 3.333$, $Y_A = 3.333$, $X_C = 3.333$ $Y_C = 3.333$.

Point A in Figure 1 illustrates these production combinations for both the U.S.A. and China. Since the total units produced of Goods X and Y are the same for both countries, the per capita consumption of each American consumer is ten times as much as his Chinese counterpart, i.e., $x_A = 0.333$, $y_A = 0.333$, $x_C = 0.0333$, $y_C = 0.0333$. Thus, the utility of each consumer in the United States is 0.333, as compared to 0.0333 for the

Chinese consumer. In other words, the standard of living for Americans as measured in per-capita units of utility is ten times that of the Chinese laborer.

Now, assume that the two countries open their borders for free trade. Assume no transportation costs. Since the two utility functions are identical, the United States specializes in its comparative advantage commodity, Good Y, and China specializes in Good X. In this case, the World Production Possibility Frontier (PPF_W) is given by the following equations (See Figure 1):

$$Y = 15 - 0.5\,X \qquad \text{for } 0 < X < 10$$

$$Y = 30 - 2\,X \qquad \text{for } 10 \leq X < 15 \tag{4}$$

The United States produces 10 units of Good Y and China produces 10 units of Good X (Point O, for Open, in Figure 1).

Assuming the terms of trade ratio to be 1: 1, each country exports and imports one half of its production to each other. Total consumption in the two countries is equal to $X_A = 5$, $Y_A = 5$, $X_C = 5$, $Y_C = 5$. Each American laborer now consumes 0.5 units of X and 0.5 units of Y, and each Chinese worker consumes 0.05 of each good, X and Y. Thus, the standard of living for both American and Chinese workers increases by 50 percent, as a result of opening the borders. Note that in this example, it is still true that American workers are consuming ten fold more than the Chinese workers under the above terms of trade assumption. It should be emphasized, however, that terms of trade other than 1X : 1Y, would give different ratios of relative gains.

III.1 Technological Change in China

Scenario 2: A Significant Technological Improvement in the Chinese Imported Commodity That Leads to a Switch in Specialization

Assume that now China acquired a new technology that causes its citizens to produce Good X and Good Y as follows: The productivity in producing Good X has not changed for a Chinese worker, but he is now six times more productive than before in the production of Good Y, i.e., he can produce 0.3 units of Good Y. Thus, the PPF for China is given by the equation:

(5) $10X + 3.333Y = 100$, or

(6) $Y = 30 - 3X$

Assuming that there are no technological changes in the United States, the autarky equilibrium in the U.S. does not change, whereas in China the autarky equilibrium is now $X_C = Y_C = 7.5$, thus $x_C = y_C = 0.075$ and $u_C = 0.075$.

Under free trade, the World Production Possibilities Frontier changes to:

$Y = 40 - 2X$ for $0 < X < 5$

(7) $Y = 45 - 3X$ for $5 \leq X < 15$

Following the conditions above, the new total production by the two countries is: X = Y = 11.25 units (Point O") in Figure 2. This point is attainable by switching the specialization of the United States from producing Good Y to a specialization in Good X. In this case, the United States can produce only 5 units of Good X; the remaining 6.25 units of Good X are now produced in China. In addition, China produces all 11.25 units of Good Y.

We pause for a moment and disregard the assumption of perfect competition that will lead to a specific terms of trade that we will discuss later. Instead, it is assumed that the two countries are involved in mutual discussions and bargaining processes to determine the terms of trade after the technological improvements. This scenario that one may call Nash (Nash, 1951), or Nash–Coase bargaining model (Coase, 1960), does represent the ongoing negotiations among countries at the beginning of the 21^{st} century. The competitive equilibrium will be presented later in the paper.

Following the bargaining apparatus, suppose that the term of trade is P_Y/P_X and is equal to 0.4, which is in-between the domestic, U.S.'s price ratio of 0.5, and the foreign, China's price ratio of 0.333. These price ratios are at pre-trade autarky equilibrium. Under this term of trade's condition, the consumption of good Y in China is:

(8) Y_C = 11.25 – (Y exported to the USA) = X_C = 6.25 + (X imported from the United States),

Where Y_C and X_C are consumptions of Y and X, respectively in China, and where China produces 11.25 units of Y and 6.25 units of X.

Based on the above terms of trade, the following equation is satisfied:

(9) X imported from the U.S. = 0.4Y exported to the United States.

Equations (8) and (9) imply:

(10) Y_C = 11.25 – 2.5(X imported from the U.S.A.)

= 6.25 + (X imported from the U.S.A.) = X_C.

Thus,

(X imported from the U.S.A.) = 1.428571

and

$X_C = Y_C = 7.678571$

The new per-capita utility for China, u_C, is equal to: $u_C = 0.076785$

As for the Unites States,

$$X_A = 5 – 1.428571 = 3.571429 = Y_{A.}$$

Thus, the new American's per-capita utility is equal to 0.3571429.

The comparison between the American and Chinese consumer for the three cases - before trade, after trade, and after the technological change in China - looks as follows:

u_C after the technological improvement in China = 0.076785 > u_C before technological change with trade = 0.05 > u_C under Autarky = 0.0333.

u_A before technological change with trade = 0.5 > u_A after the technological improvement in China = 0.3571429 > u_A under Autarky = 0.333.

The above results are summarized in the following claim.

Claim

If the globalization process leads to a transmission of technological know-how to less developed economies, the less developed countries will benefit even if the developed countries may still have an absolute technological advantage in some or all products. However, it is possible that it leads to a switch in specialization in the developed countries. In this case, the developed country is worse off from the globalization situation compared to the pre-technological improvements in the underdeveloped country. Still, it is beneficial for the developed country to engage in trade. ■

This claim is not only valid under the "bargaining" framework, but also under the competitive-equilibrium scenario when terms of trade are most favorable for the United States because China does not specializes whereas the United States produces only Good X. Consider this competitive case, where the **only** terms of trade after the technological improvement in China is in a ratio of P_Y/P_X that is equal to the internal price ratio in China, and thus equal to 0.333, i.e., the United States imports 3 units of Good Y for one unit of the exported Good X. In this case:

(10') $Y_C = 11.25 - 3(\text{X imported from the U.S.A.})$

$= 6.25 + (\text{X imported from the U.S.A.}) = X_C$.

Thus, X imported from the United States = 1.25. It follows that $X_C = 6.25 + 1.25 = 7.5$, where 6.25 units are the Chinese production of Good X and 1.25 is the quantity of Good X imported from the U.S. $Y_C = 11.25 - 3.75 = 7.5$, where 11.25 is the total production of Good Y in China and 3.75 is the number of units of Good Y exported to the U.S.

The comparison between the American and Chinese consumer for the three cases - before trade, after trade, and after the technological change in China - now looks like this:

u_C after the technological improvement in China = 0.075 > u_C before technological change with trade = 0.05 > u_C under Autarky = 0.0333.

u_A before technological change with trade = 0.5 > u_A after the technological change in China = 0.375 > u_A under Autarky = 0.333.

The scenario described above is the best in terms of trade from the U.S. point of view. Still, the technological improvement in China that leads to specialization-switching translates to a welfare reduction for U.S. citizens.

The conclusion is that in the case of a technological improvement in China, which causes China to switch its specialization patterns, the United States faces a loss. This conclusion is still valid in the extreme case, when the terms of trade before and after the technological improvement in China have not changed. The Chinese do benefit in this case from the technological improvement, but not from the terms of trade following this improvement.

One notes that the pre-technological-progress utility was calculated at the arbitrary 1:1 term of trade. With some other terms of trade, the U.S. per capita utility can be greater after the Chinese technological progress than before the progress. In any event, the United States never loses welfare compared to refraining from trade. However, the point to emphasize is that this paper presents a scenario where the United States is worse off as a result of the China's improved technology.

Scenario 3: A Small Technological Improvement in the Chinese Imported Commodity that does not Lead to a Switch in Specialization

We now turn to the case where the technological improvement in China is in the product that China initially imported, prior to the technological improvements, which will not lead to changes in specialization. This motivates China to continue importing Good Y from the U.S., since the U.S. still has a comparative advantage in that good. Based on the assumption of 1:1 consumption which eliminates the possibility for the substitution effect, the new terms of trade have not changed as a result of the improvement in China. In this scenario, both countries will not benefit from the improvement. The intuition is that since China specializes in Good X and all the improvement occurs in Good Y, which

China is importing anyway, neither of the countries benefit from the technological improvement. Figure 3 illustrates this case.

U.S. under Autarky: $Y = 10 - 2X$

China under Autarky: $Y = 5 - 0.5 X$

The World Under Trade: $Y = 15 - 0.5 X$ for $0 < X < 10$, and

$Y = 30 - 2X$ for $10 \leq X < 15$.

Point O is on the intersection of the two equations above of the world under trade;

On the 45-degree line $Y = X$

China after the technological improvements:

(11) $Y = 10 - X$

The World PPF after the technological improvements:

$Y = 20 - X$ for $0 < X < 10$.

(12) $Y = 30 - 2X$ for $10 \leq X < 15$.

Thus, the Chinese will remain at the same place before and after trade as far as their consumption bundle. Note that in case where the 1:1 assumption is not valid, a technological improvement in the Y industry leads to greater potential profitability in Y production. Therefore, more of Good Y would be produced, its price would fall, and consumption substitution toward Y would occur. This would lead to gains in trade. However, what is innovative in the above scenario is that it is shown that technological improvements do not change the welfare of the two countries at all. Even though the potential improvement in technology has occurred, neither country benefited.

Scenario 4: Technological Improvement in the Chinese Exported Commodity

We turn to the case where China improves in X, a commodity that China initially had a comparative advantage in and thus exported to the United States. If the terms of trade do not change, both countries benefit from the technological improvements.

Assume a technological improvement in China of 100 percent only in Good X. In this case, the Chinese will have comparative advantage in Good X after the improvement just as it had before the improvement. In a closed market, the PPF for China is:

(13) $Y = 5 - 0.25X$

Since, we assume full complement goods, if $X_C = Y_C$ then in a closed autarky market, $X_C = 4$, as compared with $X_C=Y_C = 0.333$ in a closed market before the technological improvement.

The new open market world's Production Possibilities Frontier, PPF_W is:

$Y = 15 - 0.25 X$ for $0 < X < 20$

(14) $Y = 50 - 2X$ for $20 \leq X < 25$

The new world's production level moves from the point O to O' (Figure 4). At point O', $X = Y = 12$. The main question is how the total world production is allocated between the two countries. One possibility that may results from a bargaining process is that the consumption of X and Y is divided between the two countries evenly so, $X_A = X_C=Y_A=Y_C = 6$. So, $u_A = 0.6$, $u_C = 0.06$, representing improvement in both countries as a result of the technological change. This will occur if the U.S. specializes and produces only 10 units of Good Y while China produces, after the improvement, 2 units of Good Y and 12 units of Good X. China exports 6 units of X for 4 Units of Y. The United States under this bargaining framework, exports 4 units of Y for 6 units of X. The terms of trade are thus, $P_X/P_Y = 4/6 = 0.666$.

Alternatively, if one adopts the competitive equilibrium apparatus, i.e., if the terms of trade are $P_X/P_Y = 4$, which is the domestic autarky price in China, the United States specializes in Good Y and produces 10 units of that good. China produces 12 units of Good X and 2 units of Good Y. The equation for the terms of trade is given by:

(15) $Y = 15 - 0.25\,X \qquad \text{for } 0 < X \leq 20$

and the consumption equilibrium is $Y = X$.

Thus, in this scenario, the consumption of the United States is 8 units of imported-good X and 8 units of Y, leaving 2 units of Good Y to be exported to China. China is left with 4 units of Good X and 4 units of Good Y, two units of Good X from domestic Chinese production, and 2 units of Good Y imported from the United States. Each American citizen's utility is thus,

$u_A = 0.8$ and $u_C = 0.04$.

The comparison between the two American and Chinese consumers for the three cases - before trade, after trade, and after the technological change in China - has now changed to:

u_C before technological improvement in China with free trade = 0.05 > u_C after the technological improvement in China in both autarky *and* under free trade = 0.04 > u_C under Autarky before technological improvements = 0.0333.

u_A after the technological improvement in China with free trade = 0.8 > u_A before technological improvements change with trade = 0.5 > u_A under Autarky = 0.333.

As a result of the above changes in technological improvements in China, China does not benefit from trade. Moreover, relative to the pre-technological improvement in China, the Chinese consumer is worse off in the trade situation. However, the American consumer benefits from the Chinese technological improvements.

Scenario 5: The Case of Specific Factors in Production

The above analysis was based on the Ricardian (1817) assumption that workers in each country are homogeneous, each worker can produce both goods, and each has the same productivity. In the following, consider the case in which factors of production are completely specific to a particular industry. Each worker is able to produce only Good X or only Good Y, but not both commodities. Assume that in the United States there are two types of workers: 8 workers specializing in producing Good Y, each producing 1 unit of Good Y and 2 laborers who are specializing in Good X, each producing 1 unit of Good X. In China, 80 workers specialize in Good X, each producing 0.1 units of Good X, and 20 workers specialize in Good Y, each producing 0.1 units of Y.

Figure 5 demonstrates this case, where PR_U represents the potential production of the U.S. and PR_C represents the potential production of China. Similar to the previous analysis, assume that the utility function is a fixed proportion utility function (perfect complement goods in a ratio of 1:1). In Autarky, the production and consumption levels in the U.S. are 2 units from each good, leaving 6 American workers unemployed. In China, the production and consumption are the same, i.e., 60 workers are unemployed. Point A (for Autarky) in Figure 5 illustrates the optimum consumption point for each of the countries, U.S. and China.

Assume that the Government distributes the national pie equally, i.e., all ten of the American workers either employed or not, share it, each receiving 1/10, and similarly the 100 Chinese consumers each consume 1/100 of the product. The utility level of an American consumer is given by, $u_A = 0.2$ and a Chinese consumer by $u_C = 0.02$.

Assume that the two countries are again involved with some bargaining and negotiation discussions with regards to the terms of trade. For simplicity, assume that each has the same power over its trading rival. Under open trade, the terms of trade are likely to be 1:1, which would result in a PPF_W given by the equation:

(16) $Y = 10 - X \quad \text{for } 2 \leq X \leq 8$

This leads both countries to move to point O in Figure 5, where the consumption of each country increases to $X_A = Y_A = X_C = Y_C = 5$. The last result leads to full employment of workers in both countries. The U.S. exports 3 units of Good Y for 3 units of Good X and vice versa for China. The utility for each American after trade is thus $u_A = 0.5$ and $u_C = 0.05$.

Assume that China has improved its technology in the imported Good Y by 100 percent. The new production level in the open market situation in China is PR'_C in Figure 5. The new equation for PPF_W is:

(17) $Y = 9.333 - 0.666X \quad \text{for } 2 \leq X \leq 8.$

Under the new terms of trade, $P_Y/P_X = 1.5$. Assume that China leads the trade, indicating optimal new consumption at Point O' where $X_C = Y_C = 5.6$. China exports 2.4 units of X to the U.S. for 1.6 units of imported Y. This leaves the Chinese per-capita utility of $u_C = 0.056$ which is higher than before the technological improvement, where $u_C = 0.05$ which is in turn higher than in Autarky where $u_C = 0.02$. The United States follows and moves toward a new consumption bundle by exporting 1.6 units of Y for 2.4 units of imported X (Point O" in Figure 5). The new consumption bundle of all Americans is 4.4 units of Good X and 4.4 units of Good Y, leaving two American workers unemployed. The per-capita American utility after the technological improvement in China is $u_A = 0.44$ which is less than before the improvement where $u_A = 0.5$ but still higher than under autarky $u_A = 0.2$.

III.2 Propositions Regarding Technological Improvements

The above examples are generalized in the following propositions.

Proposition 1

As long as the international price ratio has not changed, a technological improvement in China that does not change the pattern of specialization between the two countries will not affect the United States.

However, it is more likely that the technological improvement that causes the change in specialization of China will indeed change the international price ratio. This is because the improvement in the Chinese technology in previously U.S. imported goods reduces its dependency on imports. China's negotiation power may be altered by its reduction in the dependency of imported goods from the United States. If so, this may lead to a new international price ratio that is closer to the U.S.'s autarky price ratio. In turn, this would lead to an increase in China's standard of living as a consequence of the increased productivity in China and a consequent decrease in the standard of living in the

United States. Even without a reversal in the specialization patterns in the two countries, this will be the case.

Furthermore, if the technological improvement is related to the item in which China has been specializing and exports to the United States, then both countries may benefit from opening their markets to free trade regardless of changes that may occur in the international price ratio.

Proposition 2

If the improvement in technology by China is in its previously imported good, such that the autarky internal price ratio is now equal to the autarky price ratio in the United States, then there will be no trade between the two countries. Thus, relative to the pre-innovation equilibrium, the Unites States loses all the benefits of trade she had enjoyed prior to the Chinese innovation, while China gains from the improvement in technology. This case leads to elimination of trade. In such a case technological improvement is not beneficial to either country.

Proposition 3

A further increase in Chinese productivity of the commodity for which the United States previously had a relative advantage will lead to a shift in specialization in which each country now specializes in the product that its counterpart country previously specialized. This shift in specialization leads to a reduction in the welfare of United States residents. The costs to the United States may become even more damaging if China can favorably negotiate its terms of trade with the United States. Moreover, even if the productivity of China is still lower in both products, i.e. the United States has maintained its absolute advantage in both goods, this proposition will be valid. In spite of the fact that the U.S. loses, trade continues to flourish, since its elimination leads to an even greater loss to the U.S.

Proposition 4

A trade between a country that is more populated and a country that is less populated will lead to greater benefit for the relatively less populated country. Furthermore, if the less populated country acquires the advantage of new negotiations with the weaker, more populated country, the terms of trade will be more favorable with respect to the stronger and less populated country. The increase in standard of living will also be larger in this less populated country. Thus, the gap between the two countries' standard of living increases as a result of the technological changes.

IV. Effects of Population Growth

In this sub-section, the effect of an increase in the population size of China is studied. Although technically an increase in population is similar to an increase in productivity as far as the aggregate PPFs, there is a difference in per-capita levels of production, income and utility measures.

Assume there is a population growth of 50 percent in China. This implies 50 percent of workers as well as consumers. In autarky, initially, the PPF for China is:

(2) $10X + 20Y = 100$

Once the population increases:

(2') $10X + 20 Y = 150$

In autarky, following Ricardo, $X_C = Y_C = 7.5$ which is distributed equally among 150 consumers, thus $u_C = 0.05$ similar to the per-capita utility before the increase in population.

However, once markets are opened, the new PPF_W is:

$Y = 17.5 - 0.5\,X \qquad \text{for } 0 < X < 15$

(18) $Y = 40 - 2X \qquad \text{for } 15 \leq X < 20$

Full complement utility functions, for consumers in both countries, requires an optimality condition where X = Y. Substituting this condition into the equation above yields:

Total Production of X and Y = 11.666 in the World. This is distributed by full specialization in the United States, $X_A = 10$, and $Y_A = 0$, while China produces both goods, $X_C = 1.666$, and $Y_C = 11.666$. The U.S.'s consumption equation is given by:

(19) $X^C{}_A = X_A -$ X exported to China = 10 – X exported to China

(20) $Y^C{}_A =$ Y imported from China

where $X^C{}_A$ and $Y^C{}_A$ are the consumption of Good X and Good Y, respectively by the U.S.

Similarly the Chinese consumption of Goods X and Y are equal to:

(21) $X^C{}_C = X_C +$ X imported from the U.S. = 1.666 + X imported from the U.S.

(22) $Y^C{}_C = Y_C -$ Y exported to the U.S. = 11.666 - Y exported to the U.S.

Assuming that the terms of trade remains 1:1, the equilibrium is:

$X^C{}_A = Y^C{}_A = 5$, i.e., no change in the American welfare after the increase in the Chinese population. As for China, $X^C{}_C = Y^C{}_C = 6.666$, which is now distributed among 150 consumers, thus u_C after the increase in population = 0.0444 < u_C before the increase in population = 0.05.

The globalization process exposes China to trade which reduces the Chinese per capita utility consumption as the population of China increases. The United States is not affected in this example.

The above provides some rationale to the Chinese one-child policy, which intends to restrain the growth of the population. This policy, which increases the per-capita welfare in China and improves the benefits it might get from international trade and globalization, may hurt the citizens of the United States.

V. Implications and Conclusion

Under globalization, the United States is exposed to technological improvements by underdeveloped countries. This paper shows that this trend may possibly be harmful to the American economy or to citizens of the industrialized West. If technological changes occur in China, which alter the terms of trade in a way that leads to switching the imported and exported items in both countries, it may lead to different welfare implications for both countries and may cause harm to the developed country (such as the U.S.). Yet, what we would like the reader to take from this is not that free trade may harm the American economy, but that the policy recommendations are in the direction of improving the competitiveness of the United States in particular, and the West in general.

Improving competitiveness, a phrase that has almost disappeared in the last two decades from international economics textbooks, has clear and forceful micro and macro economic policy implications. Microeconomic polices (maybe of macroeconomic dimension) have to do with improving the quality of the labor force in the Unites States, investing in education, and research and development.[4] If the United States will lose its competitiveness in this area, we will offer our children less than we could have given them. The way to compete with these newly emerging markets is by investing more in domestic human capital.

According to a special report about China by *BusinessWeek* (December 6, 2004), nearly every manufacturer in the United States, from furniture makers to networking-gear producers, is vulnerable to Chinese competition. Whereas China and India have long been known as places to cheaply produce textile-products, clothes and toys, they are now providing the West with other goods and services such as low cost drugs (Santini, 2004). Pharmaceutical companies, overwhelmed by the rising cost of creating drugs, are turning to China and India, where it is less expensive to conduct research and development (R&D) activities. This expansion towards producing goods that are intensive in R&D is opening a new frontier in outsourcing.

More drug companies have found that China and India, where doctorate-level scientists command a salary of only $25,000 a year (one tenth of what their colleagues in the West earn), are good localities to test drug compounds and their efficacy. According to the China Pharmaceutical Economy Research Center, the percentage of big drug companies' R&D budgets outsourced to a third party has increased from 15 percent in 1990, to 35 percent in 1995, to 50 percent in the year 2000 (Kronholz,, 2004). The market for pharmaceutical and biotechnology outsourcing was valued at $100 billion in 2006 and is expected to reach $168 billion by 2009 (*The Financial Express,* 2007).[5]

Investing more in domestic human capital will constitute a dramatic change to the direction that the Unites States and other developed Western countries are currently headed. According to a recent international math comparison survey, the U.S. scored near the bottom of the survey (Kronholz, 2004). According to a recent Organization for Economic Cooperation and Development (OECD) Survey, called the Program for International Student Assessment, PISA, fifteen-year olds in the U.S. rank near the bottom of industrialized countries in both math and problem-solving skills (Kronholz, 2004). The U.S. is ranked 24th among 29 countries that are members of the OECD. Furthermore, the percentage of top-achieving math students in the U.S. is about half that of other industrialized countries. This trend, if persistent, will undermine the U.S. dominance in technology-related fields.

The results of this paper do not imply that the United States should refrain from free trade. The results presented do suggest that the United States needs to prepare its labor force for the challenges ahead in order for the U.S. to be able to compete in a more globalized world. In addition, this paper, in our opinion, pinpoints the important factors involved in peacefully incorporating and integrating the Chinese economy with the world economy. This, needless to say, is one of the most important strategic issues of the new millennium. With the new Obama Administration in the U.S. and with the deepening of the financial and economic crisis worldwide, it is no wonder that the effects of globalization and outsourcing today fascinate theoretical scholars as well as the business community and policy makers.

Notes

1. Leger (1993) in this Journal uses a version of the Ricardian Model, in which an extra market serves as a barrier to labor movement. The existence of this additional market gives rise to demands for protectionist policies. See also, the classical work by MacDougall (1951), the works by Davis (1995), Dornbusch, Fischer and Samuelson (1977), Dosi, Pavitt and Soete (1988), Golub and Hsieh (2000) and more recently the work by Gramm (2004). Gramm, in this Journal, highlights the inappropriateness of using the Hechksher-Ohlin model as a short-run explanation of trade. He incorporates imperfect factor mobility between two industries where reallocating inputs can be costly, and finds that his model performs better than the Hechksher-Ohlin framework. Similarly, Hirsch and Niron, (2000) in this Journal, reject the Heckscher-Ohlin theory and use a simple gravity model to predict the trade potential of what they called distance-sensitive products to test the Arab-Israeli trade potential once peace will arrive to the region.

2. The empirical test of the Heckscher-Ohlin model was first performed and later rejected by Nobel Laureate Leontief (1953), in his famous Leontief Paradox. Krugman and Obstfeld (2009) remark on the Leontief Paradox that it is the biggest piece of evidence against the Heckscher-Ohlin model. These negative results are confirmed by later studies as well; see for example, Baldwin (1971), the extensive work by Bowen, Leamer and Sveikauskas (1987), and Trefler (1995). Commenting on the work by Trefler (1995), Krugman and Obstfeld (2009) observe that "many trade economists now believe that this puzzle can be resolved only by dropping the Heckscher-Ohlin assumption that technologies are the same across countries" (page 75).

3. It is still worthwhile to note, however, following Samuelson (2004), that the qualitative conclusions also remain valid after adding to Ricardo's labor-only technologies the post-1930 *multifactor* trade models. These models pioneered by Heckscher, Ohlin (1933), Viner (1923), Haberler (1985), Stolper-Samuelson (1941), McKenzie (2002), Jones (1971) and others, as well as earlier works by Marshall and Edgeworth *multifactor* trade models will reach similar results as far as inter country affects on national incomes. Just as multifactor Dornbusch-Fischer-Samuelson (1980) nicely generalized the Dornbusch-Fischer-Samuelson (1977) Ricardian labor-only paradigm, the qualitative results of the scenarios presented do apply as well to multifactor as to labor-only scenarios, in regards to the distribution of welfare between the two trading partners. See Samuelson (1948, 1949, 1972a, 1972b, 1974, 1981), and Samuelson and Swamy (1973).

4. This paper shies away from macroeconomic policies, as did Samuelson (2004), who left his policy implications to the intellect of the readers. One policy issue is the value (or, the over-value) of the dollar relative to other currencies hurting U.S.'s competitiveness as it tries to spring out of a recession (see, for example, Baily and Lawrence, 2005).

5. For an extensive study that examines and evaluates the determinants of the increase in Chinese competitiveness in the world in general and relative to other East Asians countries, see Adams, Gangnes and Shachmurove (2006).

References

Adams, F. Gerard, Gangnes, Byron, and Shachmurove, Yochanan, (2006), "Why is China so Competitive? Measuring and Explaining China's Competitiveness," *The World Economy,* 29(2), February: 95-122.

Baily, Martin N. and Lawrence, Robert Z. "What Happened to the Great U.S. Job Machine? The role of Trade and Electronic Off-shoring," *Brooking Papers on Economic Activity*, 2005.

Baldwin, Robert (1971). "Determinants of the Commodity Structure of U.S. Trade," *American Economic Review*, 61, March, 126-145.

Bhagwati, Jagdish, (2004A), *In Defense of Globalization*, Oxford University Press, New York, New York.

Bhagwati, Jagdish N. (2004B), "In Defense of Globalization: It Has a Human Face," *Rivista di Politica Economica*, vol. 94, no. 11-12, November-December 2004: 9-20.

Bhagwati, Jagdish N. (2004C), "Anti-globalization: Why?" *Journal of Policy Modeling*, vol. 26, no. 4, Special Issue June 2004: 439-63.

Bhagwati, Jagdish; Panagariya, Arvind; Srinivasan, T N., (2004), "The Muddles over Outsourcing," *Journal of Economic Perspectives*, vol. 18, no. 4, Fall 2004: 93-114.

Bowen, Harry P., Edward E. Leamer, and Leo Sveikauskas (1987). "Multicountry, Multifactor Tests of the Factor Abundant Theory," American Economic Review 77, December: 791-809.

Coase, Ronald H. (1960). "The Problem of Social Cost". *Journal of Law and Economics* 3 (1): 1–44.

Davis, Donald (1995). Intraindustry Trade: A Heckscher-Ohlin Ricardo Approach," *Journal of International Economics*, 39, November: 201-226.

Dornbusch, Rudiger, Stanley Fischer and Paul A. Samuelson. 1977. "Comparative Advantage, Trade, and Payments in a Ricardian Model with a Continuum of Goods." *American Economic Review*. December, 67, pp. 823–39. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 5*. Cambridge, Mass.: MIT Press, 1986, chapter 316.

Dornbusch, Rudiger, Stanley Fischer and Paul A. Samuelson. 1980. "Heckscher-Ohlin Trade Theory with a Continuum of Goods." *Quarterly Journal of Economics*. September, 95, pp. 203–24. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 5*. Cambridge, Mass: MIT Press, 1986, chapter 317.

Dosi, Giovanni, Keith Pavitt, and Luc Soete (1988). The Economics of Technical Change and International Trade. Brighton: Wheatsheaf.

Golub, Stephen, and Chang-Tai Hsieh (2002). “Classical Ricardian Theory of Comparative Advantage Revisited.” Review of International Economics, 8(2): 221-234.

Gomory, Ralph E. and William J. Baumol. *2000. Global Trade and Conflicting National Interests*. Cambridge, Mass.: MIT Press.

Gramm, Teresa Beckham, (2004), “Factor Reallocation Costs and Tests of the Heckscher-Ohlin Trade Theory.” *International Trade Journal*, vol. 18, no. 3, Fall: 147-76.

Haberler, Gottfried (1985), *The Theory of Comparative Costs and Its Use in the Defense of Free Trade*, Selected Essays of Gottfried Haberler. 1985, pp. 3-19.

Heckscher, Eli F; Ohlin, Bertil, (1933), *Heckscher-Ohlin Trade Theory*, Translated, edited, and introduced by Harry Flam and M. June Flanders Cambridge, Mass. and London: MIT Press, 1991: x, 222.

Hirsch, Seev; Hashai, Niron, (2000). “The Arab-Israeli Trade Potential: The Role of Distance-Sensitive Products.” *International Trade Journal*, vol. 14, no. 1, Spring: 1-35.

Irwin, Douglas. 2004. “‘Outsourcing’ is Good for America.” *New York Times*. January 28, Op-ed.

Irwin, Douglas 2002. *Free Trade Under Fire*, Princeton and Oxford: Princeton University Press: x, 257.

Jones, Ronald W., (1971), "A three-Factor Model in Theory, Trade, and History," in Jagdish Bhagwati et al., eds., *Trade, Balance of Payments, and Growth, Amsterdam*: North Holland, 1971: 3-21.

Johnson, George E. and Frank P. Stafford. 1993. “International Competition and Real Wages.” *American Economic Review.* May, 82: 127–30.

Kronholz, June (2004) “Economic Time Bomb: U.S. Teens Are Among Worst at Math,” *Wall Street Journal*, December 7, Page B1.

Krugman Paul and Maurice Obstfeld (2009). *International Economics: Theory and Policy*. Eighth Edition, Pearson, Addison Wesley, New York.

Kuznets, Simon. 1946. *National Income: A Summary of Findings*. New York: NBER.

Leontief, Wassily (1953) “Domestic Production and Foreign Trade: The American Capital Position Re-Examined,” *Proceedings of the American Philosophical Society*,97: 331-349.

Leger, Lawrence A. (1993). “Land Rents and the Demand for Protection,” *International Trade Journal*, vol. 7, no. 4, Summer: 435-62.

Luthje, Teit (2006) “Vertical Specialization between Developed and Developing Countries: A Modification of the Heckscher-Ohlin Model.” *International Trade Journal*, vol. 20, no. 4, Winter: 407-27.

MacDougall, G.D. A. (1951). “British and American Exports: A Study Suggested by the Theory of Comparative Costs.” *Economic Journal*, 61, December: 697-724; 62 (September 1952): 487-521.

McKenzie, Lionel W. (2002), *Classical General Equilibrium Theory*, Cambridge and London: MIT Press, 2002: xiii, 318.

Nash, John (1951) "Non-Cooperative Games" *The Annals of Mathematics* 54(2):286-295.

Ohlin. Bertil. 1933. *Interregional and International Trade*. Cambridge, Mass.: Harvard University Press.

Ricardo, David. 1817. *On the Principle of Political Economy and Taxation*. London: John Murray, 1821. Volume 1 in P. Sraffa, ed., with the assistance of M. H. Dobb, *The Works and Correspondence of David Ricardo*. Cambridge: University of Cambridge Press, 1953.

Rybczynski, Tadeusz M. 1955. “Factor Endowments and Relative Commodity Prices,” *Economica*, 22: 336-341.

Samuelson, Paul A. 1948. “International Trade and Equalisation of Factor Prices.” *Economic Journal.* June, 58, pp. 163–84. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 2.* Cambridge, Mass.: MIT Press, 1977, chapter 67.

Samuelson, Paul A. 1949. “International Factor-Price Equalisation Once Again.” *Economic Journal.* June, 59, pp. 181–97. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 2.* Cambridge, Mass.: MIT Press, 1977, chapter 68.

Samuelson, Paul A. 1972a. “Heretical Doubts About the International Mechanism.” *Journal of International Economics.* September, 2, pp. 443–54. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson*, Vol. 4. Cambridge, Mass.: MIT Press, 1977, chapter 256.

Samuelson, Paul A. 1972b. “International Trade for a Rich Country.” Lectures before the Swedish-American Chamber of Commerce, New York City, May 10. Stockholm: Federation of Swedish Industries. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 4.* Cambridge, Mass.: MIT Press, 1977, chapter 250.

Samuelson, Paul A. 1974. “Complementarity: An Essay on the 40th Anniversary of the Hicks-Allen Revolution in Demand Theory.” *Journal of Economic Literature.* December, 12, pp. 1255–289. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 4.* Cambridge, Mass.: MIT Press, 1977, chapter 208.

Samuelson, Paul A. 1981. “To Protect Manufacturing?” Zeitschrift fu¨r die gesamte Staatswissenschaft (*Journal of Institutional and Theoretical Economics*). September, 137, pp. 407–414. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 5.* Cambridge, Mass.: MIT Press, 1986, chapter 324.

Samuelson, Paul A. 2004. “Where Ricardo and Mill Rebut and Confirm Arguments of Mainstream Economists Supporting Globalization.” *Journal of Economic Perspectives—* Volume 18, Number 3, Summer: 135–146.

Samuelson, Paul A. and S. Swamy. 1973. “Invariant Economic Index Numbers and Canonical Duality: Survey and Synthesis.” *American Economic Review*. August, 64, pp. 566–93. Reproduced in *The Collected Scientific Papers of Paul A. Samuelson, Volume 4.* Cambridge, Mass.: MIT Press, 1977, chapter 209.

Santini, Laura (2004). "Drug Companies Look to China for Cheap R&D." *The Wall Street Journal,* November 22, Page B1.

Stolper, Wolfgang F; Samuelson, Paul A., (1941), "Protection and Real Wages." *Globalization and Labour Markets*, Volume 1. 2001: 3-18.

“The new outsourcing pill,” (2007) May 14, *The Financial Express*, available at: http://www.financialexpress.com/news/the-new-outsourcing-pill/166308/0, access on March 18, 2009.

Trefler, Daniel (1995). “The Case of the Missing Trade and Other Mysteries,” *American Economic Review*, 85, December: 1029-1046.

Viner, Jacob (1923), *Dumping: A problem in international trade*, Reprints of Economic Classics. Fairfield, N.J.: Kelley, 1991: xiii, 343.

FIGURE ONE: The Baseline Model

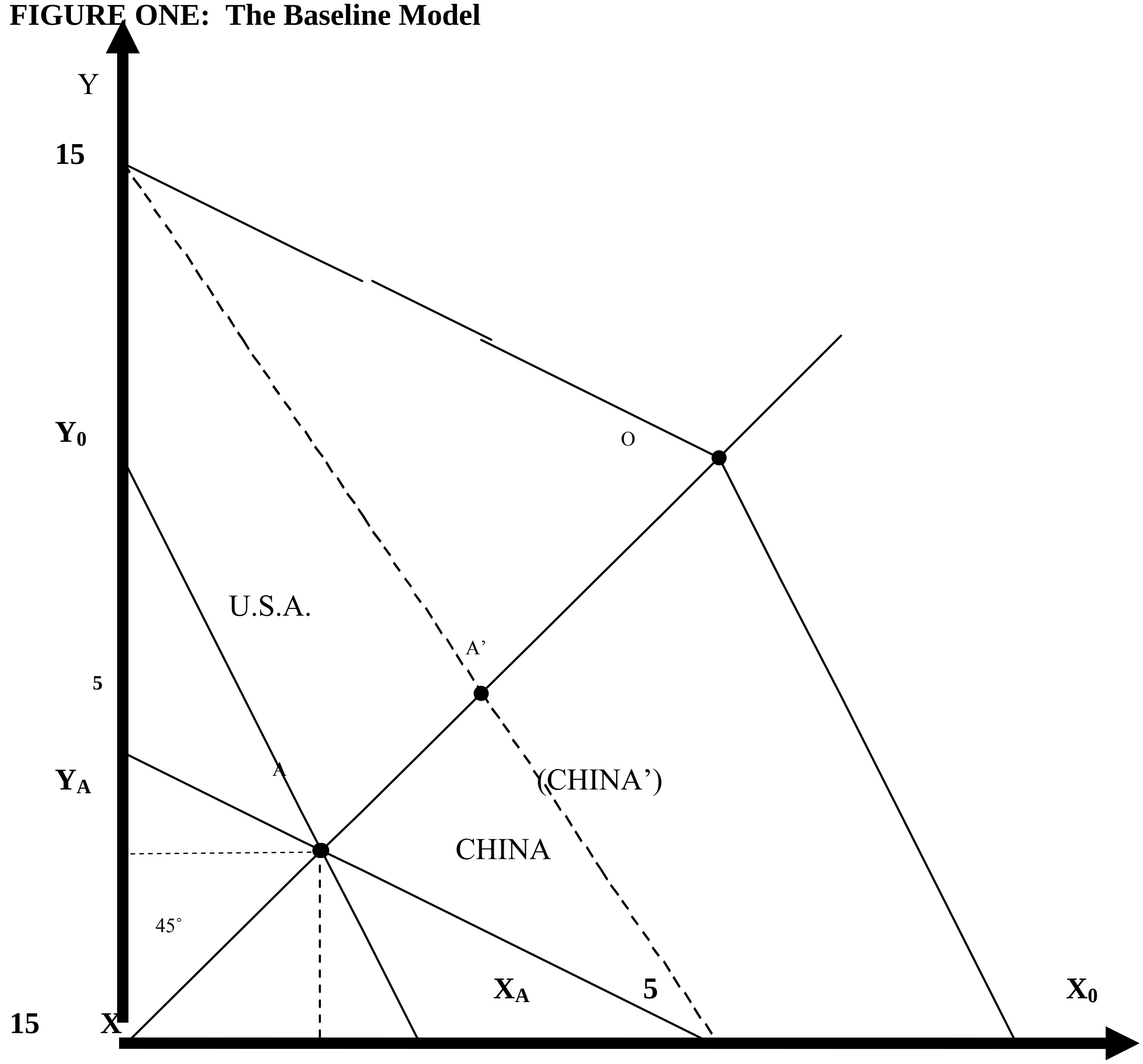

FIGURE TWO: Technological Improvement in the Imported Good - Specialization Switching

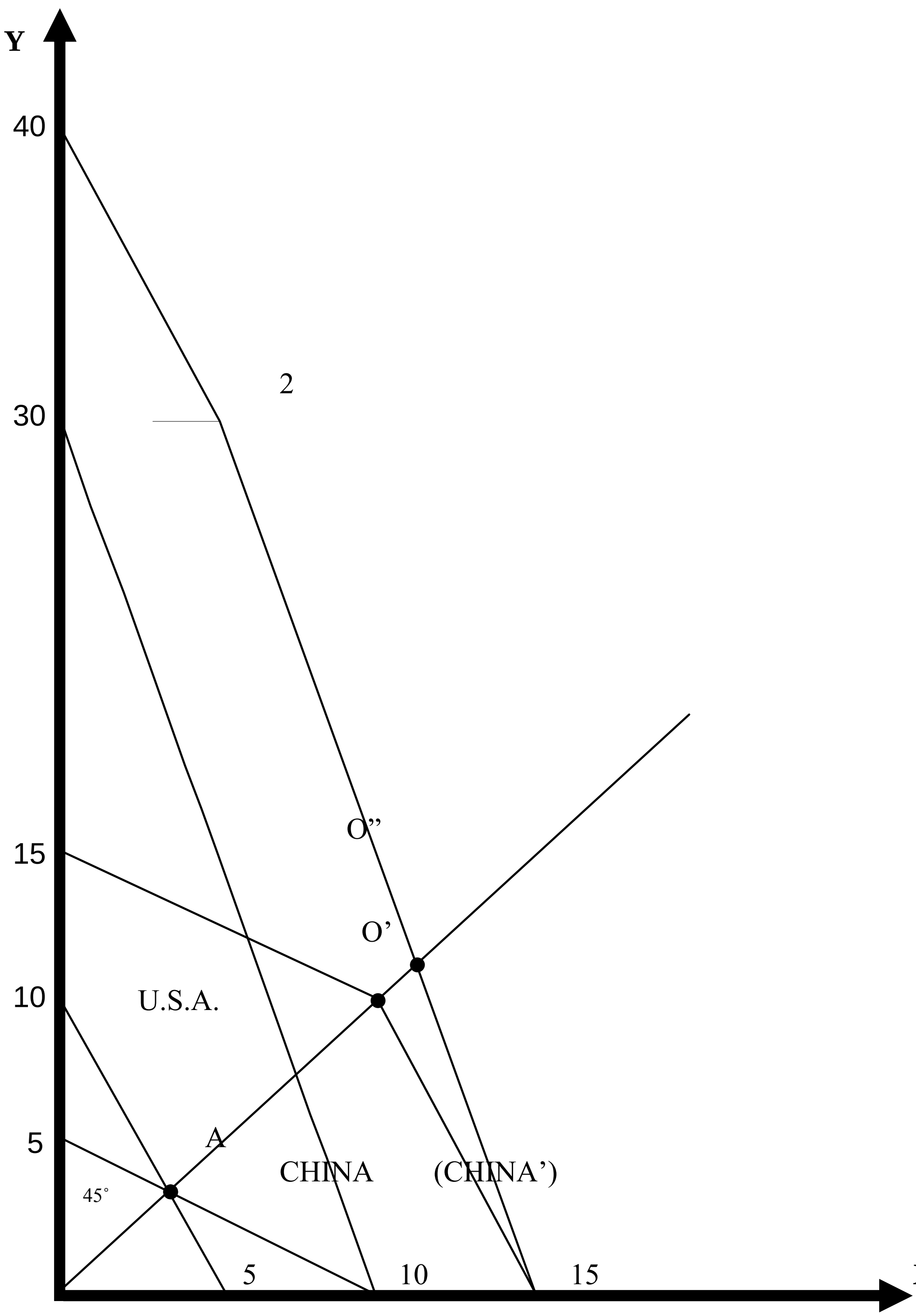

FIGURE THREE: Technological Improvement in the Imported Good – No Specialization Switching

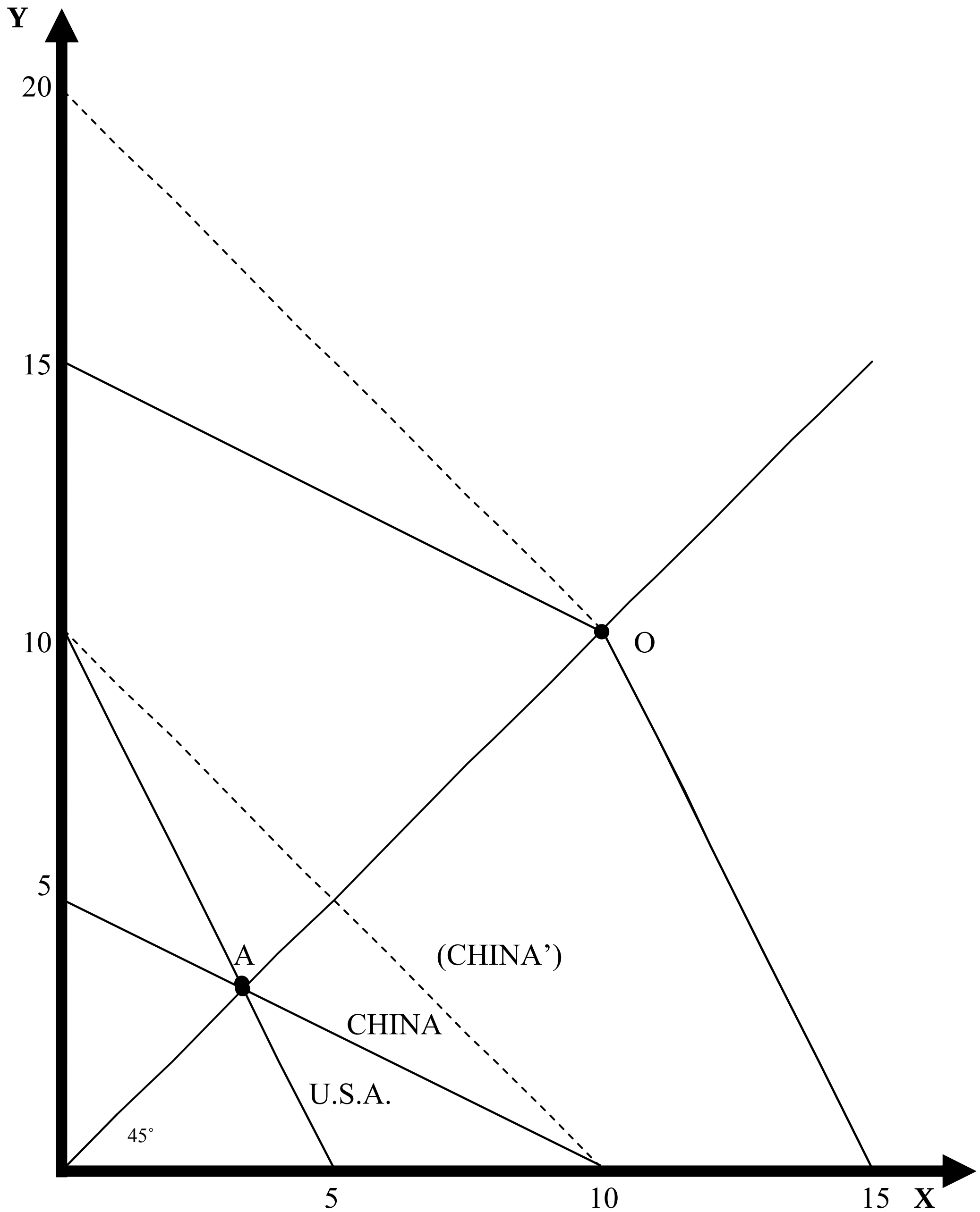

FIGURE FOUR: Technological Improvement in the Exported Good

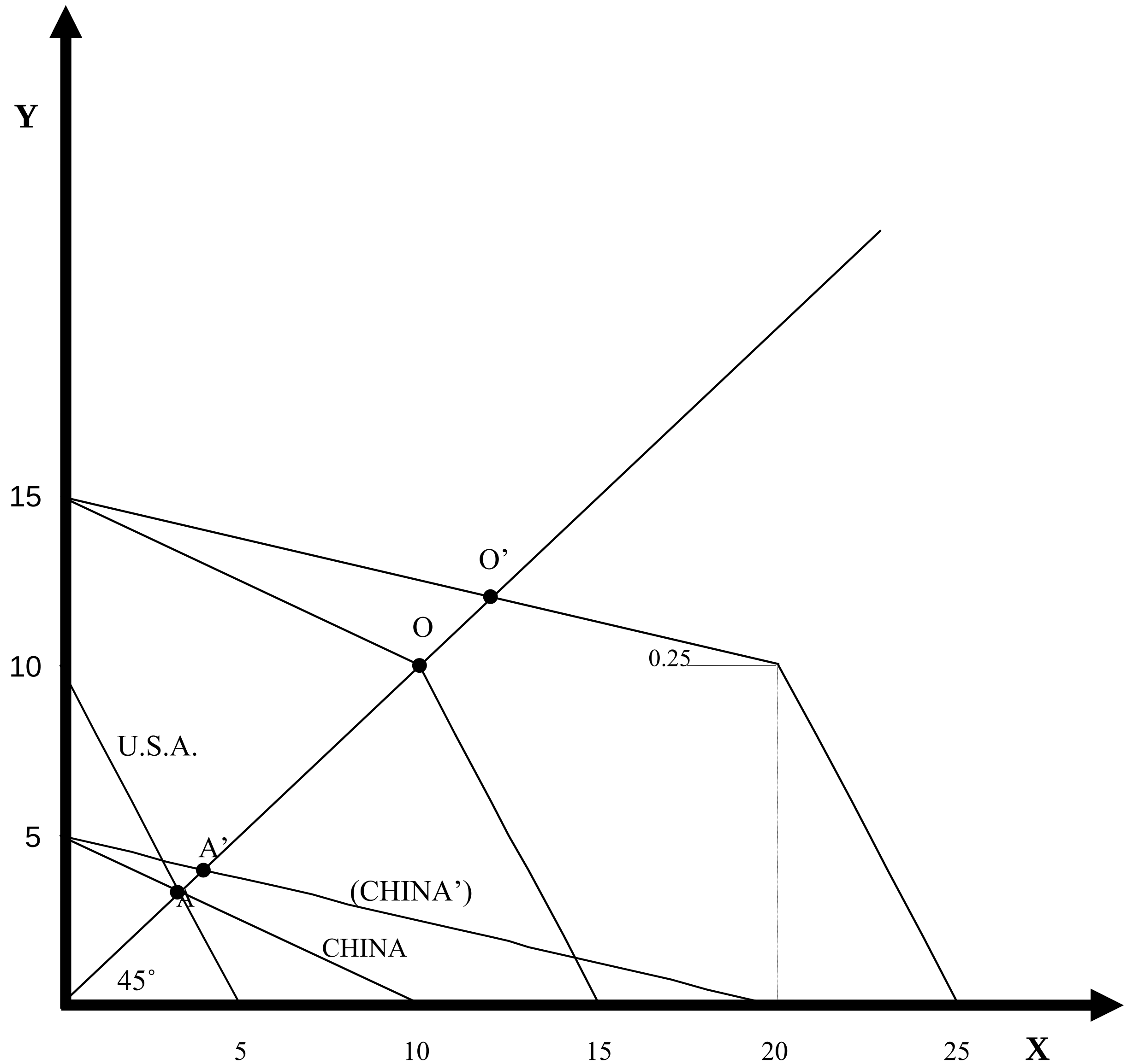

FIGURE FIVE: The Case of Specific Factors in Production